Measuring scope 3 carbon emissions

Waste and water

January 2012/01

A guide to good practice

hefce
HIGHER EDUCATION FUNDING COUNCIL FOR ENGLAND

Contents

Executive Summary

Purpose

1. This guidance provides higher education institutions (HEIs) with information on how to calculate scope 3 carbon[1] emissions generated by water and waste. It aims to help HEIs adopt efficient and effective data collection practices and includes examples of good practice within the HE sector.

Key points

2. In January 2011 HEFCE commissioned work to assist in measuring scope 3 emissions from HEIs in England. Ove Arup and Partners Ltd (Arup) and De Montfort University were appointed to provide:

- a set of draft data definitions to measure scope 3 carbon emissions from waste and water within the Estate Management Statistics (EMS) reporting system
- good practice guidance supporting the draft definitions to help HEIs adopt efficient and effective data collection practices in order to measure their scope 3 emissions
- a report that provides necessary background information, findings, justification for the choice of definitions and recommendations.[2]

3. This document presents the good practice guidance noted above, which is intended to help HEIs measure their water and waste scope 3 emissions. The document includes:

- background to carbon emissions associated with water and waste
- information on the new water and waste definitions for the EMS monitoring system
- step-by-step guidance for measuring carbon emissions associated with water, wastewater and waste
- worked examples for estimating carbon emissions for water and waste
- opportunities for improving water and waste data collection
- carbon conversion factors
- case studies from the HE sector
- other sources of guidance and support.

4. This guidance has been developed following extensive research, consultation and analysis. From the research, it is clear that the methods identified for measuring carbon emissions associated with water, wastewater and waste require good data collection and management by HEIs. Improving the robustness of data collection will improve the accuracy of reported emissions. Accurate measurement enables institutions to understand how they consume water and generate waste, and helps them identify areas where simple changes could make significant impacts on cost and environmental efficiency.

5. The method for measuring carbon emissions associated with water and waste is based on the guidelines for greenhouse gas (GHG) company reporting of the Department

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1 In this document 'carbon' is used as shorthand for greenhouse gas emissions.

2 'Measuring scope 3 carbon emissions – waste and water. Report to HEFCE by Arup and De Montfort University'. Available at www.hefce.ac.uk.

for Environment, Food and Rural Affairs (Defra) and the Department of Energy and Climate Change (DECC)[3]. It was considered that this methodology would provide consistency and the ability to monitor long-term changes in practice towards resource efficiency in the HE sector.

6. Many HEIs have good data on water and wastewater, reported through the EMS. Calculating carbon emissions associated with water and wastewater is therefore likely to be a relatively straightforward case of multiplying water and wastewater data by the relevant carbon conversion factor.

7. In contrast, the scope of data collection amongst HEIs in relation to waste and recycling data are varied in terms of quantity and quality. A tiered approach to measuring carbon emissions from waste has therefore been identified, which is accessible to institutions with very limited data on waste through to institutions with good quality data.

8. To support institutions in calculating their scope 3 emissions there are sample emissions calculations in Annex C and a detailed research report[4], which is a 'sister' document to this Good Practice Guide. Guidance on measuring scope 3 emissions from transport is contained in 'Measuring scope 3 carbon emissions – transport. A guide to good practice' (HEFCE 2012/02).

Action required

9. HEIs will be able to report scope 3 carbon emissions from water and waste through the Estate Management Statistics, collected by the Higher Education Statistics Agency (HESA), from 2012-13.

[3] '2010 Guidelines to Defra / DECC's GHG Conversion Factors for Company Reporting'. Available at www.defra.gov.uk/environment/economy/business-efficiency/reporting/.

[4] See footnote 2.

1. Introduction

Context

1.1 The Climate Change Act 2008 proposes that the UK's net greenhouse gas (GHG) emissions account for the year 2050 is at least 80 per cent lower than the baseline 1990 level. The Act also proposes a minimum interim target of a 34 per cent cut in emissions by 2020, together with 5-year carbon budgets for 2008-12, 2013-17 and 2018-2022.[5] As a significant contributor to public sector emissions, the higher education (HE) sector will be expected to take a lead role in reducing emissions.

1.2 The public sector in England is at the forefront of carbon accounting worldwide, as described below.

- Department for Children, Schools and Families (DCSF) (2007-10): the sector level carbon emissions footprint was completed in 2007-08, with (subsequently) a sector level carbon trajectory and associated strategic plan
- National Health Service (NHS) England (2008-10): a full scope 1-3 emissions footprint was completed in 2008-09 , estimating the sector emissions at around 20 million tonnes (Mt) CO_2e. A follow-on carbon analysis study projected NHS England GHG emissions to 2020
- Department for Environment, Food and Rural Affairs (Defra) (2010): Central Government sector level scope 1, 2 and 3 consumption-based GHG emissions (including procurement) were calculated for a 19-year time series (1990 to 2008)
- Higher education sector (2008-10): in 2009 HEFCE commissioned a sector level emissions study for all scope 1-3 emissions, excluding procurement.

1.3 In February 2009, HEFCE published an updated strategic statement and action plan on sustainable development.[6] This document set out its vision that the sector would become and be recognised as 'a major contributor to society's efforts to achieve sustainability – through the skills and knowledge that its graduates learn and put into practice, its research and exchange of knowledge through business, community and public policy engagement, and through its own strategies and operations'.

1.4 Through widespread consultation with the HE sector, HEFCE facilitated the setting and adoption of carbon reduction targets for scope 1 and 2 emissions.[7] The sector level targets are a 43 per cent reduction by 2020 and 83 per cent by 2050 against a 2005 baseline. The 'Carbon reduction target and strategy for higher education in England' (HEFCE 2010/01) includes commitments to:

- measure a baseline of carbon emissions from procurement by December 2012[8]
- set sector level target(s) for scope 3 emissions by December 2013.

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5 For more information on carbon budgets see www.theccc.org.uk/carbon-budgets.

6 'Sustainable Development in Higher Education: 2008 update to strategic statement and action plan' (HEFCE 2009/03). All HEFCE publications are available at www.hefce.ac.uk.

7 'Carbon reduction target and strategy for higher education in England' (HEFCE 2010/01).

8 'Measuring scope 3 carbon emissions – supply-chain (procurement). Report to HEFCE on sector emissions by Arup, CenSA and De Montfort University. Available at www.hefce.ac.uk.

1.5 Higher education institutions (HEIs) are expected to set their own targets for carbon reduction, and HEFCE has linked capital funding to performance against carbon management plans.[9] It is important to manage scope 3 emissions, as the studies identified above show that these comprise most of the carbon emissions within organisations.

1.6 Estate Management Statistics (EMS) are collected by the Higher Education Statistics Agency (HESA).[10] HESA is undertaking a record review of EMS in 2011-12 and this will include sector consultation in early 2012. Data on scope 3 carbon emissions will be included in EMS from 2012-13. The proposed new definitions referenced in this document may change as part of this review.

1.7 'Measuring and monitoring scope 3 emissions in higher education. Report to HEFCE by Arup and De Montfort University – water and waste'[11] provides details of the research that underpins this Good Practice Guide. Guidance on measuring scope 3 emissions from transport is contained in 'Measuring scope 3 carbon emissions – transport. A guide to good practice' (HEFCE 2012/02).

Terminology

1.8 This section explains the various terms, key concepts and boundaries described in the guidance.

1.9 Greenhouse gas emissions: Carbon dioxide (CO_2) is the dominant GHG mainly due to the large volumes emitted. However, other GHGs included within the Kyoto Protocol are relevant to consider: methane (CH_4) and nitrous oxide (N_2O), not only because of their high global warming potential (GWP)[12] (Table 1), but also because these gases are largely emitted in wastewater treatment and waste disposal (landfill). Conversion factors used in this guidance are presented in carbon dioxide equivalent (CO_2e) on the basis of their global warming potential.[13]

Table 1: Global warming potential of selected greenhouse gases

Greenhouse gas (GHG)	Global warming potential (GWP)
Carbon dioxide (CO_2)	1
Methane (CH_4)	21
Nitrous oxide (N_2O)	310

9 'Arrangements for the second Capital Investment Framework' (HEFCE Circular letter 17/2010).

10 Further information on the Estates Management Statistics is available at www.hesa.ac.uk under EMS Stream.

11 See footnote 2.

12 Global Warming Potentials (GWPs) are used to compare the impact of the emission of equivalent masses of different GHGs relative to carbon dioxide.

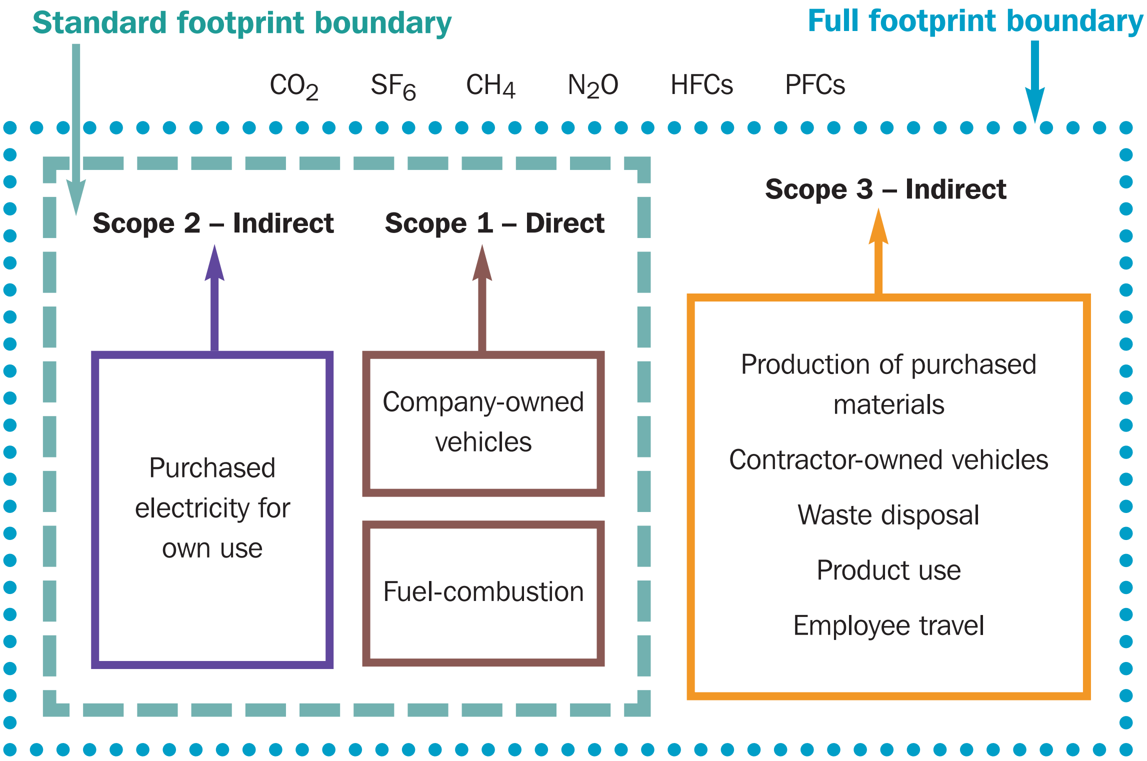
13 Based on the 2011 Defra / DECC's Greenhouse Gas Conversion Factors for Company Reporting guidelines. Available at www.defra.gov.uk/environment/economy/business-efficiency/reporting/. These factors include the six GHGs of the Kyoto Protocol (CO_2, CH_4, N_2O, hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride). The GWP factors are consistent with the reporting under the Kyoto Protocol and the second assessment report of the Intergovernmental Panel on Climate Change (IPCC) for a 100-year time horizon.

1.10 The 'Greenhouse Gas Protocol' (also known as the GHG Protocol),[14] developed by an initiative convened by the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD), is the most commonly used standard for corporate GHG emissions reporting worldwide. It provides the accounting framework for nearly all GHG standards in the world and, therefore, is used by most companies that produce GHG emissions inventories. The GHG Protocol 'Corporate Accounting and Reporting Standard' categorises emissions as being scope 1, 2 or 3, as defined below:

- Scope 1 emissions: direct GHG emissions occurring from sources owned or controlled by the company. Examples include vehicle fleet emissions, on-site emissions from boilers, and combined heat and power (CHP) energy generation
- Scope 2 emissions: GHG emissions from off-site generation of electricity, heat and/or steam used by the company
- Scope 3 emissions: an optional reporting category for all other indirect emissions, which are a consequence of the company's activities but occur from sources not owned or controlled by the company.

Figure 1 shows the breakdown of emissions categories according to the GHG Protocol.

Figure 1: GHG Protocol classification of emissions



Source: Clean Air-Cool Planet and Forum for the Future (2008)[15]

[14] 'The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard (revised edition)' (WRI/ WBCSD 2004). Available at www.wri.org/publication/greenhouse-gas-protocol-corporate-accounting-and-reporting-standard-revised-edition.

[15] 'Getting to Zero: Defining Corporate Carbon Neutrality' (Clean Air-Cool Planet and Forum for the Future, 2008). Available at www.cleanair-coolplanet.org/documents/zero.pdf.

Structure of the guidance

1.11 This guidance is presented in the following sections:

- **Section 2:** Carbon emissions associated with water use
- **Section 3:** Carbon emissions associated with waste
- **Section 4:** Other sources of guidance and support

2. Carbon emissions associated with water use

2.1 Carbon emissions from water use are associated with the energy used in supplying water and from wastewater treatment processes. These emissions are classified under scope 3, because they occur in utilities that supply water to institutions or treat the wastewater they discard.

2.2 The water industry currently emits around 5 million metric tonnes of carbon dioxide equivalent (Mt CO_2e) per year due to the energy and process emissions for water and wastewater pumping and treatment. This is almost one per cent of UK GHG emissions from 23 companies.[16] The Environment Agency estimates that emissions related to electricity use for treating sewage are expected to increase as the population grows, people adapt to climate change and higher environmental and water quality standards needs to be met.

Data collection for water

2.3 Information on water volume can be obtained from utility company bills or from automatic meter readings (AMR) where this facility has been installed. AMR provides more reliable data because it produces confirmed readings, rather than the estimates on which water utility company bills are often based. To improve the accuracy of water volume figures, manual meter readings should periodically be taken instead of only using estimates.

2.4 It is not easy to calculate the volume of wastewater sent for treatment unless it is monitored and metered. Utility companies often use estimates based on the volume of water supplied to calculate the volume of wastewater disposed of and treated. This varies, but is usually between 90 per cent and 95 per cent of the water use volume. Providing metering to measure the amount of wastewater sent for treatment will increase the accuracy of the figures. Several institutions have begun to do this.

Measuring carbon emissions associated with water use

2.5 The proposed new definitions for scope 3 carbon emissions associated with water supply and wastewater treatment use existing data collected through the EMS[17] as shown in Table 2.

Table 2: Relevant existing EMS definitions related to water

Reference	Indicator	Short description
D32	Water and wastewater costs	The cost (£) of supplying and treating water and wastewater respectively in a financial year. Include metered water supply, wastewater charge, trade effluent charge and water rates. Reported for non-residential buildings (C13), residential buildings (C14) and the total estate (C1).
D38b	Water consumption	The annual volume, measured in cubic metres (m^3), of metered fresh water consumed. Where possible, data are sub-divided to reflect the residential and non-residential estate.
D77a	Water supply of greywater and rainwater	The annual volume, measured in cubic metres (m^3), of non-mains water supply for potable and non-potable used by an institution from rainwater and greywater.
D77b	Water supply from borehole extraction	The annual volume, measured in cubic metres (m^3), of non-mains water supply for potable and non-potable use by an institution from borehole extraction. Borehole volume should be reported as the volume taken, not the licensed volume.

16 'A low carbon water industry' (Environment Agency, 2011). Available at: www.environment-agency.gov.uk/research/library/publications/114393.aspx.
17 See footnote 15.

2.6 The proposed new definitions involve applying the relevant carbon conversion factor provided by Defra and DECC to the reported water data as explained in Table 3.

Table 3: Description of the proposed new EMS definitions for carbon emissions associated with water use

New EMS definition	New EMS definition details
Water supply carbon emissions	Carbon emissions associated with the supply of water consumed by the HEI. The water consumption figures returned under D38b should be converted to kilograms of carbon dioxide equivalents (kg CO_2e) using the relevant carbon conversion factor (see Annex A, Table A1).
Wastewater treatment carbon emissions	Carbon emissions associated with wastewater treatment. Charges for wastewater treatment are usually based on a figure derived from a percentage of the total water consumption. Utilities typically apply a factor of 90-95 per cent to calculate wastewater costs based on water consumption. Carbon emissions associated with wastewater treatment are estimated by multiplying the wastewater volume by a conversion factor. To provide a figure for wastewater volume, institutions should use the following data sources: • Meter readings from all meters on-site related to wastewater volume and trade effluent • If the water utility contracted by the institution provides a factor to calculate the wastewater volume based on the water supply volume, use the factor provided by the water utility. Otherwise, water consumption figures returned under D38b can be multiplied by 95 per cent (as a default value). The figure for wastewater volume should be added to values reported in D77a Water supply 'greywater' and rainwater and D77b Water supply borehole extraction. This figure should be converted to kilograms of carbon dioxide equivalents (kg CO_2e) using the relevant carbon conversion factor (see Annex A, Table A1).

Carbon emissions from water use

2.7 You can calculate emissions from water use by multiplying the data for the water use volume by the appropriate carbon conversion factor (CF) (see Annex A, Table A1) to give a figure reported as kg CO_2e per unit of water used.

$$GHG_{\text{water supply}}\ [kg\ CO_2e] = \text{water consumption volume}\ [m^3] * CF_{\text{water supply}}\ [kg\ CO_2e/m^3]$$

These emissions account only for water supplied by water companies. Do not include water volumes from rainwater recycling and borehole extraction in this calculation. While a small amount of electricity would be used to store and pump greywater, rainwater and borehole water, emissions from this within institutions are accounted for in scope 2.

2.8 If data are available for the non-residential (C13) and residential estate (C14), it is recommended to estimate carbon emissions from water consumption separately and add emissions for the total estate (C1).

2.9 A worked example of how to calculate carbon emissions associated with an HEI water supply is available in Annex C (worked example 1).

Carbon emissions from wastewater

2.10 You can calculate emissions from wastewater by collecting data on the volume of mains water used as well as data on the volume of water used in rainwater recycling and borehole extraction. This information needs to be collected, as rainwater and borehole water are likely to be disposed off down the sewer.

2.11 Estimate carbon emissions associated with the treatment of wastewater by multiplying the wastewater volume by the conversion factor related to wastewater treatment shown in Table A1 (in Annex 1).

$GHG_{wastewater}$ *[kg* CO_2*e] = Total wastewater volume [m*^{3}*] * CF* $_{wastewater}$ *[kg* CO_2*e/m*^{3}*]*

2.12 To get a figure for wastewater volume, institutions should use the following data sources:

- meter readings from all meters on-site related to wastewater volume and trade effluent (if available)
- if the water utility company contracted by the institution provides a factor to calculate the wastewater volume based on the water supply volume, use it. Otherwise, water consumption figures returned under D38b can be multiplied by 95 per cent (as a default value).

2.12 Add the figure for wastewater volume to values reported in D77a Water supply greywater and rainwater and D77b Water supply borehole extraction. Take into account all wastewater flows that go to treatment, including these additional ones.

Total wastewater volume = wastewater volume from water consumption + greywater volume + rainwater volume + borehole extraction water volume

2.13 Water supply data from the EMS definitions D77a and D77b may refer to the total estate (C1), so assumptions on how much water is used in the non-residential and residential estate may be inaccurate. It is recommended to estimate carbon emissions derived from wastewater for the entire estate (C1).

2.14 A worked example of how to calculate the carbon emissions associated with an HEI's water treatment is available in Annex C (worked example 2).

Opportunities for improving data collection for water

2.15 Detailed data collection provides a higher level of accuracy when reporting water and wastewater usage and the subsequent carbon emissions calculations.

2.16 Manual meter readings: A better understanding of water usage within an HEI can lead to better management, potentially reducing costs. It can also provide more detailed figures from which to calculate related carbon emissions. One way of getting better information is through meter readings from on-site water meters. By reading meters once a month the organisation can build up a better picture of water usage across its estate and compare this to billed information to highlight incorrect charging. Whilst this is a more resource- and time-intensive approach than AMR, it does provide useful data on water usage. This can improve the accuracy of GHG calculations from water and wastewater use.

2.17 Automatic meter readings: AMR provides many benefits compared to traditional estimated readings:

- increased accuracy as they are based on actual, verifiable readings rather than estimates
- reduced administration costs through cutting time spent querying invoices and payments
- consumption issues are quickly identified as AMR can provide alerts when consumption rises or falls below certain parameters to identify leaks or other issues
- better budgeting control and forecasting as it provides a better understanding of water consumption within the institution.

Case Study: **Automatic meter reading**

The importance of water conservation is growing as climate change and population factors simultaneously increase water demand and reduce availability. In addition, purification processes involved in providing a clean water supply generate GHG emissions, contributing to climate change. In response to these issues, De Montfort University (DMU) took a strategic approach to monitoring and measuring water and energy usage by installing half-hourly metering for gas, electricity and water.

Since February 2008, when the AMR system was installed, DMU has discovered benefits beyond monitoring and measuring consumption. For example, leaks can be identified immediately using alarms set up on the AMR system. In winter 2010, the system enabled DMU staff to detect leaks in unoccupied buildings within hours, significantly reducing damage to the properties. In addition, the consumption data also proved useful when claiming a rebate from the water supplier due to leaks. Following a major water leak at De Montfort in 2009, the consumption data generated by the AMR system were submitted to the water suppliers as evidence, enabling rebate entitlements to be calculated accurately.

Other benefits of the system include the ability to monitor usage against reduction targets and to check invoiced usage against the system. Furthermore, some systems automatically calculate each building's carbon emissions. As water usage is a good indicator of building occupancy, an AMR system which measures water along with energy use can also be used to identify electricity and gas wastage.

Source: De Montfort University

3. Carbon emissions associated with waste

3.1 In 2008 total waste generation in the UK was estimated at 288.6 million tonnes.[18] Defra reported that waste production is gradually declining, with the largest contribution coming from the construction and demolition sector. Of this total, 45 per cent was recovered while 48 per cent was deposited onto or into the land. The UK generated a total of 32.5 million tonnes of municipal waste in 2009, of which 49 per cent was sent to landfill. Of the remaining waste, 16.2 million tonnes of waste (50 per cent) had some value recovered by recycling, composting, reuse or energy recovery.

3.2 Local authorities report municipal waste through a system known as WasteDataFlow.[19] Municipal waste generation has been annually decreasing as has the amount of municipal waste sent to landfill, while the proportion of municipal waste sent for recycling, composting or reuse in England has increased. Despite these improvements, the UK per capita municipal waste generated was equivalent to 526kg per person in 2009, 3 per cent higher than European Union (EU) average of 512kg per person.

3.3 The waste management sector is a major contributor of GHG emissions in the UK, accounting for 17.9 Mt CO_2e (3.2 per cent of UK's total estimated GHG emissions) in 2009. Of the total GHG emissions, 89 per cent arises from landfill, 9 per cent from wastewater handling and 2 per cent from waste incineration (without energy recovery). GHG emissions from the waste sector have fallen from 59.0 Mt CO_2e in 1990 to 17.9 Mt CO_2e in 2009. Even with these reductions, the UK was still the highest GHG emitter of waste in Europe in 2007.[20] Biodegradable waste disposed of in landfill produces methane, which has a global warming potential 21 times greater than CO_2. These emissions are addressed in the UK carbon budgets and the EU Landfill Directive limits.[21]

Overview of waste management in the HE sector

3.4 The HE sector is particularly diverse in terms of physical attributes (size of institution, type and age of estate and geographical location) and focus (areas and degrees of specialism and balance between research and teaching). Therefore, HEIs vary in the amount and type of waste they produce, which is reflected in waste management arrangements.

3.5 Institutions produce a mix of municipal waste from halls of residence and commercial waste from the non-residential buildings. HEIs also produce hazardous waste, clinical waste, and waste electrical and electronic equipment (WEEE).

3.6 The importance of waste management within the HE sector has increased significantly. This is due to increased legislation for waste as a whole and the inclusion of waste related information within HE sector benchmarking tools, such as Universities that Count (now known as LiFE – Learning in Future Environments).[22]

18 'Waste Data Overview' (Defra, 2011). Available at www.defra.gov.uk/statistics/files/20110617-waste-data-overview.pdf.

19 WasteDataFlow is a system to collect information from all local authorities about the amount of waste that is collected, recycled and disposed of. The WasteDataFlow website also provides the opportunity to interrogate the data from individual local authority areas. Available at www.wastedataflow.co.uk/login.aspx.

20 'UK largest contributor to EU waste emissions', (Letsrecycle, 2010). Available at: www.letsrecycle.com/news/latest-news/waste-management/uk-largest-contributor-to-eu-waste-emissions.

21 'Waste and recycling' (Defra, 2011). Available at: www.defra.gov.uk/environment/economy/waste/.

22 For more information see www.thelifeindex.org.uk/.

Data collection for waste

3.7 Waste from non-residential buildings is usually collected by private sector waste management contractors, while waste from students' residences is often collected by local authorities or sub-contractors. Waste data are mainly collated through invoices and transfer notes, while waste compositional data can be obtained through annual waste audits or surveys.

3.8 Invoices and transfer notes should contain data on the quantity and type of waste collected. Data for waste quantities can be provided by volume or by mass. If waste quantity data are provided by volume, it is desirable to convert it into mass units, using appropriate volume to mass conversion factors.[23] Waste data for non-residential and residential buildings should be reported based on the actual figures provided by waste management contractors according to the length of contract (for example, 35-42 weeks, 50-52 weeks). Data should not be extrapolated or averaged out over a year to provide annual figures.

3.9 Understanding the composition of general waste requires sampling. Waste composition refers to the material streams within a quantity of waste that are identified and categorised. Waste compositional data should include not only waste diverted to recycling, composting or other treatment methods, but also residual waste.

3.10 Further information about waste data collection and waste audits can be found later in section 3 under 'Opportunities for improving data collection for waste'.

3.11 The research conducted by Arup and DMU showed that HEIs have a wide diversity of approaches to measuring and reporting water and waste.[24] In some circumstances the local authority collecting waste at institutions does not provide data in relation to the amount of waste collected or the compositional breakdown of the waste. This makes it difficult to calculate carbon emissions from waste across the sector, meaning a tiered approach is required.

Measuring carbon emissions associated with waste

3.12 For consistency, the selected calculation approaches for carbon emissions associated with waste are based on guidelines for GHG company reporting produced by Defra and DECC.

3.13 The proposed new EMS definition for carbon emissions associated with waste uses existing data collected through the EMS (Table 4).

Table 4: Relevant EMS definition related to waste (2009/10)

Reference	Data definition	Short description
D73	Waste mass	The annual mass (tonnes) of waste managed by the institutions in different waste disposal/treatment methods: recycling, incineration, energy recovery from waste and others. Where possible, the data are reported for non-residential buildings (C13), residential buildings (C14) and the total estate (C1). The category C15 requires information about waste mass in the mentioned disposal/treatment methods for construction, demolition and excavation waste in all works conducted in the institutions.

23 Volume to mass conversion factors can be found within the EMS definitions (see footnote 15).

24 'See footnote 2.

3.14 The proposed new EMS definition for waste (Table 5) reflects the varied data collection practices used by HEIs. It proposes three levels of reporting, 'basic', 'medium' and 'detailed', to let HEIs select a method appropriate for the level of waste data available (Figure 2). The 'detailed' approach provides the most robust measure of carbon emissions.

3.15 Each of the three approaches uses the Defra/DECC life cycle conversion factors for waste treatment and disposal (Annex A). The greater the level of detail in the available data, the greater the level of accuracy of the final results. These approaches use national waste composition datasets or in-house waste data according to the data availability, as illustrated in Table 6 and explained in Annex B.

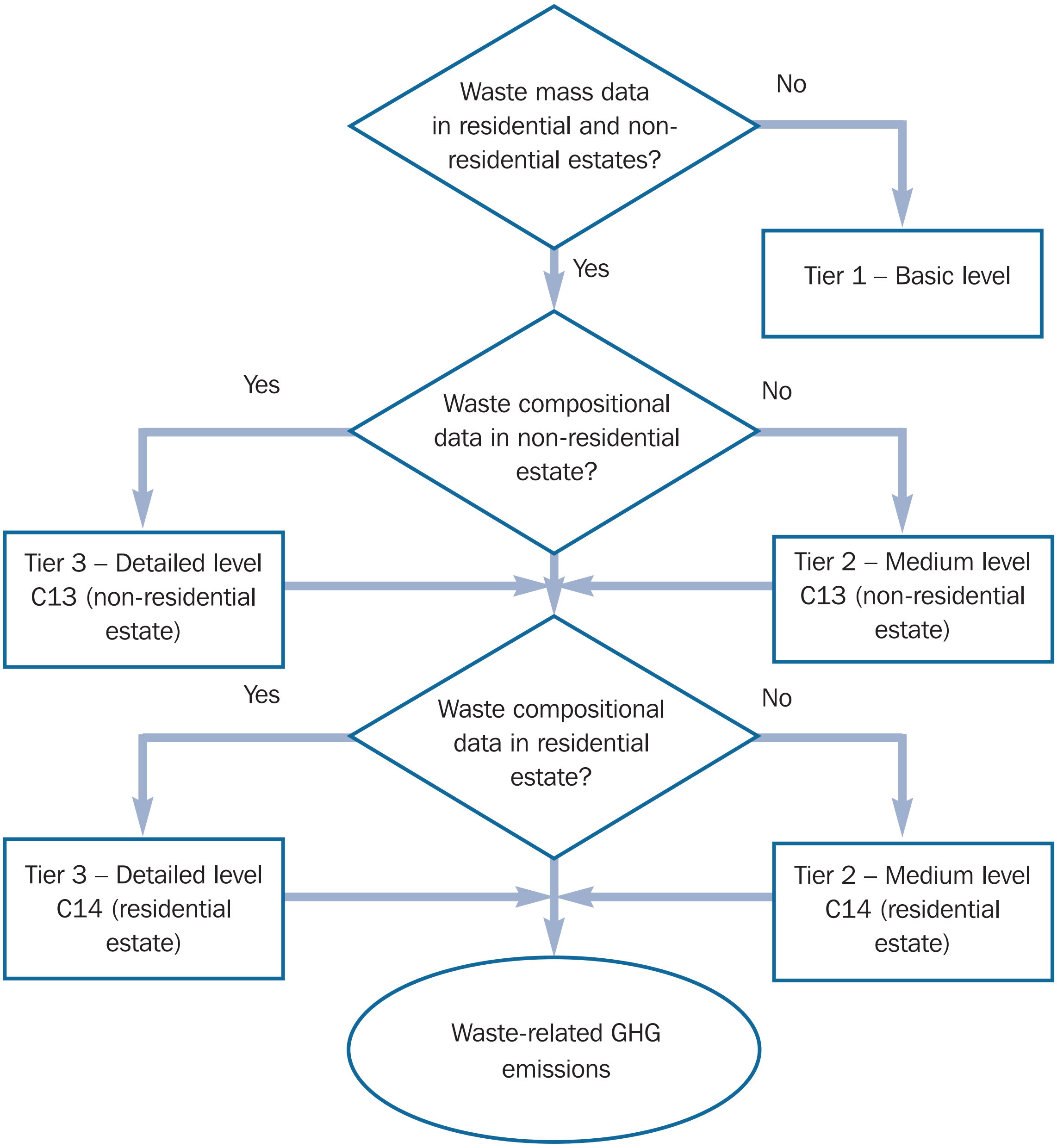
Table 5: Description of the proposed new EMS definition for waste

Data definition	Guidance
Carbon emissions from waste	Carbon emissions associated with the production and treatment of waste. The EMS seeks to calculate the carbon emissions associated with the production and treatment of waste. In this context, treatment methods include recycling, composting, energy recovery from waste, anaerobic digestion and landfill. Institutions vary widely in the scope of their data collection in relation to waste and recycling, and the composition of waste. Institutions, contractors and suppliers of management services have varying levels of data on waste, waste composition, waste volumes and recyclables composition. As a result of this diversity, a tiered approach is proposed for calculating carbon emissions from waste: • Basic approach: where waste data are very limited for both residential and non-residential properties. • Medium approach: where waste data and recycling data are available for non-residential and/or residential buildings. • Detailed approach: where good quality in-house waste data are available. To calculate carbon emissions from waste, the waste mass needs to be broken down into the relevant fractions and multiplied by their corresponding Defra/DECC life cycle conversion factors for waste treatment and disposal (see Annex A).

Table 6: Sources of compositional data for waste

Tier	Source of waste compositional data	
	Non-residential estate	Residential estate
Basic	'Mixed municipal waste' fraction from Defra 2011 GHG conversion factors	'Mixed municipal waste' fraction from Defra 2011 GHG conversion factors
Medium	Waste Watch FHE Compositional Data (2005)	Defra Municipal Waste Compositional Data (2008)
Detailed	In-house waste data	In-house waste data

Figure 2: Tiered approach to calculating GHG emissions



3.16 Carbon emissions from waste can also be estimated using a spreadsheet provided by Defra/DECC.[25] Waste mass needs to be broken down into the relevant waste fractions and entered into the relevant column of the spreadsheet. Where data are available for the treatment and disposal routes for each of the waste fractions, these can be entered into the relevant columns e.g. recycling, composting, energy from waste and landfill. The spreadsheet then calculates the carbon emissions for that waste fraction for the particular treatment and disposal route selected. The spreadsheet should be used in conjunction with the step-by-step guidance described for the tiered approaches for ease of calculation. The steps below describe the basic, medium and detailed approaches.

Basic approach to calculate carbon emissions from waste

3.17 The basic approach is to be used where waste data from both residential and non-residential properties is very limited. Due to the lack of waste compositional data, generic municipal waste data are applied. Table 7 presents step-by-step guidance on how to calculate emissions using this approach.

Table 7: Calculation of carbon emissions from waste: basic approach

Steps	Step description
	Non-residential estate
Step A	Collate the volume (m^3) of waste collected for the NON-RESIDENTIAL estate and convert it into mass units Waste volume (m^3) * volume to mass conversion factors[26] = waste mass (tonnes)
Step B	Identify the mass (tonnes) of recycled materials from NON-RESIDENTIAL properties. If waste is recycled but the quantities are unknown, apply the percentage of UK municipal waste recycled to the total mass of NON-RESIDENTIAL waste.[27] Once the mass of recycled materials has been identified or calculated apply the carbon conversion factor under the waste fraction of 'mixed municipal waste' for recycling – open loop (Annex A).
Step C	Identify the mass (tonnes) of any organic materials recovered from NON-RESIDENTIAL properties. If organic waste is recovered but the quantities are unknown, apply the percentage of UK municipal waste composted to the total mass of NON-RESIDENTIAL waste.[28] Once the mass of any organic materials has been identified or calculated apply the carbon conversion factor under the waste fraction of 'mixed municipal waste' for anaerobic digestion and/or composting (Annex A).

25 See Annex 9, Table 9d of '2011 Guidelines to Defra/DECCs Greenhouse Gas Conversion Factors for Company Reporting' (Excel) (Defra/DECC 2011). Available at www.defra.gov.uk/environment/economy/business-efficiency/reporting/.

26 Volume to mass conversion factors can be found within the EMS definitions (see footnote 15).

27 In 2009-10, 24 per cent of UK municipal waste was recycled (dry recycling). Source: Waste Data Overview (Defra, 2011). Available at www.defra.gov.uk/statistics/files/20110617-waste-data-overview.pdf. This percentage changes every year, so it is recommended to use the percentage corresponding to the particular year that carbon emissions are being calculated. This information can be found in the Waste Data Overview and in Municipal waste statistics published by Defra annually under Household waste: green and dry recycling rates. Available at www.defra.gov.uk/statistics/environment/waste/wrfg16-recycrates/.

28 In 2009-10, 15.7 per cent of UK municipal waste was composted (green recycling). Source: Waste Data Overview (Defra, 2011). Available at www.defra.gov.uk/statistics/files/20110617-waste-data-overview.pdf. This percentage changes every year, so it is recommendable to use the percentages corresponding to the particular year that carbon emissions are being calculated. This information can be found in the Waste Data Overview and in Municipal waste statistics published by Defra annually under Household waste: green and dry recycling rates. Available at www.defra.gov.uk/statistics/environment/waste/wrfg16-recycrates/.

Steps	Step description
	Non-residential estate (continued)
Step D	Identify the mass (tonnes) of waste sent for energy recovery from NON-RESIDENTIAL properties. Apply the carbon conversion factor under the waste fraction of 'mixed municipal waste' for energy from waste (Annex A).
Step E	Apply the carbon conversion factor under the waste fraction of 'mixed municipal waste' for landfill to the remaining mass (tonnes) of NON-RESIDENTIAL waste (Annex A).
Step F	Apply the carbon conversion factor under the waste stream of mixed municipal waste for the production of virgin material to the total mass (tonnes) of NON-RESIDENTIAL waste (Annex A).
Step G	Sum the carbon emissions from the production of virgin material (step F) and the net carbon emissions from various waste disposal routes (steps B to E) and report total net carbon emissions from waste and recycling in carbon equivalents (CO_2e) for the NON-RESIDENTIAL estate.
	Residential estate
Step H	Collate the volume waste collected for the residential estate and convert it into mass units: Waste volume (m^3) * volume to mass conversion factors[29] = waste mass (tonnes) If there is a lack of residential waste data, estimate the total mass (tonnes) of RESIDENTIAL waste based on the number of students (and dependent relatives) in the residential estate and the average per capita municipal waste generated in the UK.[30,31] Total waste mass (tonnes) = Number of RESIDENTIAL students * per capita municipal waste generated
Step I	Identify the mass (tonnes) of recycled materials from RESIDENTIAL properties. If waste is recycled but the quantities are unknown, apply the percentage of UK municipal waste recycled to the total mass of RESIDENTIAL waste. Once the mass of recycled materials has been calculated apply the carbon conversion factor under the waste fraction of 'mixed municipal waste' for recycling – open loop (Annex A).
Step J	Identify the mass (tonnes) of any organic materials recovered from RESIDENTIAL properties. If organic waste is recovered but the quantities are unknown, apply the percentage of UK municipal waste that is composted to the total mass of RESIDENTIAL waste. Once the mass of any organic materials has been calculated apply the carbon conversion factor under the waste fraction of 'mixed municipal waste' for anaerobic digestion and/or composting (Annex A).

29 Volume to mass conversion factors can be found within the EMS definitions (see footnote 15).

30 In 2009-10, the average municipal waste generated in the UK per person was 0.526 tonnes of waste/person. Source: 'Waste Data Overview' (Defra, 2011). Available at www.defra.gov.uk/statistics/files/20110617-waste-data-overview.pdf. This average should also correspond to the particular year that carbon emissions are being calculated. Information about UK per capita municipal waste generated can be found in 'Waste overview' also published by Defra on an annual basis.

31 The waste generation per student may vary slightly to the municipal waste generation of an average UK person not only regarding waste mass, but also in terms of waste composition (cardboard, plastic and glass bottles, etc.). Although the per capita municipal waste generation may be higher than the actual figure (HEI data), the aim of the basic approach is to provide average values to support HEIs to calculate their emissions with little data and to encourage institutions to improve their waste data collection. It could be expected that HEIs with good practice in data collection and waste management in residences could have lower per capita waste generation and higher recycling rates than the average.

Steps	Step description
	Residential estate (continued)
Step K	Identify the mass (tonnes) of waste sent for energy recovery from RESIDENTIAL properties. Apply the carbon conversion factor under the waste fraction of 'mixed municipal waste' for energy from waste (Annex A).
Step L	Apply the carbon conversion factor under the waste fraction of 'mixed municipal waste' for landfill to the remaining mass (tonnes) of RESIDENTIAL waste (Annex A).
Step M	Apply the carbon conversion factor under the waste stream of 'mixed municipal waste' for the production of virgin material to the total mass (tonnes) of RESIDENTIAL waste (Annex A).
Step N	Sum the carbon emissions from the waste production of virgin material (step M) and the net carbon emissions from various waste disposal routes (steps I to L) and report total net carbon emissions from waste and recycling in carbon equivalents (CO_2e) for the RESIDENTIAL estate.
	Total estate
Step O	Sum the net carbon emissions from waste for NON-RESIDENTIAL estate (step G) and for RESIDENTIAL estate (step N) to obtain the net carbon emissions from waste for the total estate.

3.18 A worked example on using the basic approach is in Annex C (worked example 3).

3.19 If the waste mass for the non-residential and residential estate cannot be separated, the following options are recommended:

- Option 1: Firstly, calculate emissions for the total estate based on the total waste mass following the steps indicated for the non-residential estate. Secondly, calculate emissions for the residential estate based on the number of students allocated to institution-owned accommodation. Finally, estimate emissions for the non-residential estate as the difference between the total estate emissions and the residential estate emissions
- Option 2: Only report the total estate carbon emissions from waste.

Medium approach to calculate carbon emissions from waste

3.20 The medium approach is to be used where waste and recycling data are available for non-residential and/or residential buildings. In this case, national average waste compositional data can be used for residual and general waste data sent to landfill. Waste Watch's further and higher education institutions waste compositional estimates are used for non-residential buildings, while Defra's municipal waste compositional estimates are used for residential buildings (see Annex B). Table 8 presents step-by-step guidance on how to calculate emissions using this approach.

Table 8: Calculation of carbon emissions from waste: medium approach

Steps	Step description
	Non-residential estate
Step A	Collate the volume (m^3) of waste collected for the non-residential estate and convert it into mass units: Waste volume (m^3) * volume to mass conversion factors[32] = waste mass (tonnes)
Step B	Identify which materials are recycled in NON-RESIDENTIAL buildings, providing the mass (tonnes) for each material type then apply the carbon conversion factors for recycling (Annex A). If the institution has a 'mixed recyclables' waste stream as well as recycling waste material, the institution can provide a compositional breakdown of these materials based on: • Waste contractor figures on recycling rates for different materials • HEI waste audit. The waste fractions are then added to the respective recycled waste streams. Where the compositional breakdown of the mixed recycling stream is unavailable HEIs should apply the mixed recycling tonnage to the carbon conversion factor for 'mixed municipal waste' (Annex A).
Step C	Identify which organic materials are recovered in NON-RESIDENTIAL buildings, providing the mass (tonnes) for each material type then apply the carbon conversion factors for anaerobic digestion and/or composting for each waste fraction (Annex A).
Step D	Identify which materials are sent to energy recovery in NON-RESIDENTIAL buildings, providing the mass (tonnes) for each material then apply the carbon conversion factors for energy from waste for each waste fraction (Annex A).
Step E	Apply waste compositional data breakdown for NON-RESIDENTIAL buildings (Table B1 in Annex B) to produce an estimate of the waste fraction breakdown for the remaining general waste sent to landfill. The mass (tonnes) in NON-RESIDENTIAL buildings for each material is then applied to the carbon conversion factors for landfill (Annex A).
Step F	Apply the carbon conversion factors for the production of virgin material to the mass of waste for each individual waste stream identified (Annex A).
Step G	Sum the carbon emissions from the production of virgin material (step F) and the net carbon emissions of the various fractions for each waste treatment and disposal route (calculated in steps B to E). Sum the net carbon emissions for all waste treatment and disposal routes and report the total net carbon emissions from waste in carbon equivalents (CO_2e) for the NON-RESIDENTIAL estate.
	Residential estate
Step H	Collate the volume (m^3) of waste collected for the residential estate and convert it into mass units: Waste volume (m^3) * volume to mass conversion factors[33] = waste mass (tonnes) If these data are not available, follow the steps of the basic approach (residential).

[32] Volume to mass conversion factors can be found within the EMS definitions (see footnote 15).

[33] Volume to mass conversion factors can be found within the EMS definitions (see footnote 15).

Steps	Step description
	Residential estate (continued)
Step I	Identify which materials are recycled in RESIDENTIAL buildings and apply the carbon conversion factors for recycling for each waste fraction (Annex A). If the institution has a 'mixed recyclables'[34] waste stream as well as recycling waste material, follow the options provided in step B.
Step J	Identify which organic materials are recovered in RESIDENTIAL buildings, providing the mass (tonnes) for each material type then apply the carbon conversion factors for anaerobic digestion and/or composting for each waste fraction (Annex A).
Step K	Identify which materials are sent to energy recovery in RESIDENTIAL buildings, providing the mass (tonnes) for each material type then apply the carbon conversion factors for energy from waste for each waste fraction (Annex A).
Step L	Apply municipal waste composition data (Table B2 in Annex B) to produce an estimate of the waste fraction breakdown for RESIDENTIAL buildings for the remaining general waste sent to landfill. This will provide a mass (tonnes) for each material. The carbon conversion factors for landfill can then be applied to the remaining residual waste fractions (Annex A) in RESIDENTIAL buildings.
Step M	Apply the carbon conversion factors for the production of virgin material to the mass of waste for each individual waste stream identified (Annex A).
Step N	Sum the carbon emissions from the production of virgin material (step M) and the net carbon emissions of the various waste fractions for each waste treatment and disposal route (calculated in steps I to L). Sum the net carbon emissions for all waste treatment and disposal routes and report the total net carbon emissions from waste in carbon equivalents (CO_2e) for the RESIDENTIAL estate.
	Total estate
Step O	Sum the net carbon emissions from waste for NON-RESIDENTIAL estate (step G) and for RESIDENTIAL estate (step N) to obtain the net GHG emissions from waste for the total estate (C1).

3.21 A worked example of using the medium approach is in Annex C (worked example 4).

Detailed approach to calculate carbon emissions from waste

3.22 The detailed approach is to be used where good quality in-house waste data are available. Table 9 presents step-by-step guidance on how to calculate emissions using this approach.

[34] Some waste management contractors collect recyclables in a general manner, which is usually referred to as 'commingled', 'mixed recyclables' or 'dry mixed recycling' and these are sent to a material recovery facility (MRF).

Table 9: Calculation of carbon emissions from waste: detailed approach

Steps	Step description
	Non-residential estate
Step A	Collate the volume waste (m^3) collected for the non-residential estate and convert it into mass units: Waste volume (m^3) * volume to mass conversion factors[35] = waste mass (tonnes)
Step B	Identify which materials are recycled in NON-RESIDENTIAL buildings, providing the mass (tonnes) for each material type then apply the carbon conversion factors for recycling (Annex A). If the institution has a 'mixed recyclables' waste stream as well as recycling waste material, the institution can provide a compositional breakdown of these materials based on: • Waste contractor figures on recycling rates for different materials • HEI waste audit. The waste fractions are then added to the respective recycled waste streams. Where the compositional breakdown of the mixed recycling stream is unavailable HEIs should apply the mixed recycling tonnage to the carbon conversion factor for 'mixed municipal waste' (Annex A).
Step C	Identify which organic materials are recovered in NON-RESIDENTIAL buildings, providing the mass (tonnes) for each material type then apply the carbon conversion factors for anaerobic digestion or composting for each waste fraction (Annex A).
Step D	Identify which materials are sent to energy recovery from NON-RESIDENTIAL buildings, providing the mass (tonnes) for each material type then apply the carbon conversion factors for energy from waste (Annex A).
Step E	Apply in-house waste compositional breakdown for NON-RESIDENTIAL buildings. This will produce an estimate of the waste fraction breakdown (tonnes) for the remaining waste sent to landfill. Then apply the carbon conversion factors for landfill to the remaining residual waste fractions (Annex A).
Step F	Apply the carbon conversion factors for the production of virgin material to the mass of waste for each individual waste stream identified (Annex A).
Step G	Sum the carbon emissions from the production of virgin material (step F) and the net carbon emissions of the various waste fractions for each waste treatment and disposal route (calculated in steps B to E). Sum the net carbon emissions for all waste treatment and disposal routes and report the total net carbon emissions from waste in carbon equivalents (CO_2e) for the NON-RESIDENTIAL estate.
	Residential estate
Step H	Collate the volume (m^3) of waste collected for the residential estate and convert it into mass units: Waste volume (m^3) * volume to mass conversion factors[36] = waste mass (tonnes)

35 Volume to mass conversion factors can be found within the EMS definitions (see footnote 15).

36 Volume to mass conversion factors can be found within the EMS definitions (see footnote 15).

Steps	Step description
	Residential estate (continued)
Step I	Identify which materials are recycled in RESIDENTIAL buildings and apply the carbon emission factors for recycling for each waste fraction (Annex A). If the institution has a 'mixed recyclables'[37] waste stream as well as recycling waste material, follow the options provided in step B.
Step J	Identify which organic materials are recovered in RESIDENTIAL buildings, providing the mass (tonnes) for each material type then apply the carbon conversion factors for anaerobic digestion and/or composting for each waste fraction (Annex A).
Step K	Identify which materials are sent to energy recovery from RESIDENTIAL buildings, providing the mass (tonnes) for each material type then apply the carbon conversion factors for energy from waste for each waste fraction (Annex A).
Step L	Apply in-house waste compositional breakdown to estimate the waste fraction breakdown for RESIDENTIAL buildings for the remaining general waste sent to landfill. Then apply the carbon conversion factors for landfill to the remaining residual waste fractions in RESIDENTIAL buildings (Annex A).
Step M	Apply the carbon conversion factors for the production of virgin material to the mass of waste for each individual waste stream identified (Annex A).
Step N	Sum the carbon emissions from the production of virgin material (step M) and the net carbon emissions of the various waste fractions for each waste disposal route (calculated in steps I to L). Sum the net carbon emissions for all waste disposal routes and report the total net carbon emissions from waste in carbon equivalents (CO_2e) for the RESIDENTIAL estate.
	Total estate
Step O	Sum the net carbon emissions from waste for NON-RESIDENTIAL estate (step G) and for the RESIDENTIAL estate (step N) to obtain the net carbon emissions from waste for the total estate.

3.23 A worked example of using the detailed approach is in Annex C (worked example 5).

Opportunities for improving data collection for waste

3.24 The accuracy of reporting carbon emissions from waste will improve if more accurate and more detailed data are produced for more types of waste. The Defra/DECC GHG conversion factors, illustrated in Annex A, work on data for the different waste fractions that may arise through an organisation's waste stream.

3.25 The level of detail is important not just in relation to the amount of the different waste fractions recycled, composted or sent to energy from waste, but more importantly in relation to the breakdown or waste composition of residual waste sent to landfill.

3.26 Developing enhanced waste data will improve the accuracy of an institution's carbon emissions, improve awareness and, potentially, improve on-site waste management. Collating a detailed waste stream analysis also helps an organisation understand what

[37] Some waste management contractors collect recyclables in a general manner, which is usually referred to as 'commingled', 'mixed recyclables' or 'dry mixed recycling' and these are sent to a material recovery facility (MRF).

waste it generates and identify areas where simple changes could make big impacts on cost and environmental efficiency. These changes would be introduced through a systematic resource efficiency programme to reduce, reuse and recycle more waste.

Waste audits

3.27 Greater levels of detail can be obtained through effective waste audits of the different waste fractions within the HEI's waste streams and their disposal routes. An effective waste audit can potentially provide:

- a useful baseline by which to measure progress
- greater environmental awareness amongst staff
- legislative compliance
- enhanced revenue from recycling
- maximised recycling rates
- waste compositional data for carbon calculations.

3.28 Completing a waste audit takes time, resources and commitment. A full waste audit requires separating different type of waste into different waste fractions and weighing them. The Scottish Environment Protection Agency, Eco Schools Scotland and Changeworks[38] have developed guidance on conducting waste audits. Several specialist companies can also audit waste. Many HEIs have put waste audits into the curriculum to provide practical experience to students of environmental auditing.

Case Study: **Waste audits and waste contracts**

In Spring 2010, the University of Leicester began regular meetings with Loughborough University to discuss how the institution would approach the tender for its waste management contract because the existing contract was due to expire in December 2010. The University of Leicester invited other institutions to partner with it in the tender exercise, but the HEI quickly discovered that differing time scales would prevent expanding the partnership beyond the two universities.

The University of Leicester worked in partnership with Loughborough, whose purchasing team led the tender exercise, and concluded early on that management information and potential recycling rates were as important as cost.

A scoping study of waste management companies within a 30-mile radius was commissioned and most of the companies were subsequently invited to tender. The information gathered led to splitting the tender into eight lots for different waste streams, each lot being subject to a pay-by-weight stipulation. As a result, the institution received several responses to the tender with some companies bidding for a single lot and others bidding for up to five lots, each offering pay-by-weight systems in order to provide high quality waste management data.

In addition to excellent waste management data the institution now receives from all its contractors, the University of Leicester conducts three internal waste audits

38 'The Standardised Waste Audit' (Scottish Environment Protection Agency, Eco Schools Scotland and Changeworks 2010). Available at www.ecoschoolsscotland.org/documents/FinalWasteAuditPDF.pdf.

each year (autumn/spring/summer), each providing one week of data. This allows it to look at contamination and waste composition in detail whilst providing building-specific management information and a means of verifying data supplied by waste contractors.

Two of the annual audits are conducted mainly by student volunteers. A strong base of environment team volunteers and good links with academic departments has led to a wealth of detailed information being collected over the last three years. In the summer of 2011 the institution trialled audit teams consisting entirely of cleaning staff, each auditing the buildings they predominantly work in.

In summary, the University of Leicester now has detailed composition and weight data for all waste streams and a significant number of students and staff who have engaged in waste auditing and developed a good understanding of the nature and importance of recycling and resource efficiency. The management information also provides a means of identifying and prioritising cost reduction strategies, waste reduction and recycling strategies and provides strong evidence to support business cases and strategic decisions.

Source: University of Leicester

Waste management contractors

3.29 Establishing a good relationship with waste management contractors will be beneficial to HEIs that are striving to collect good quality data on waste. Waste data may be included on invoices or provided through 'pay-by-weight' services. Where data have not been provided by waste management contractors, HEIs should ask their contractor about the feasibility of providing data.

3.30 The renewal of new waste management contracts provides an opportunity to embed new reporting and measuring procedures on waste and recycling data into arrangements with waste management contractors.

3.31 A number of institutions have waste collected by local authorities (particularly for residential properties). Local authorities often do not provide the same level of detailed waste data as private sector waste management contractors. Where waste data cannot be provided by a local authority or private sector waste management contractor, institutions should consider calculating their own estimated weights. These estimations would depend on several variables including:

- number of bins
- volume (m^3) of bins
- type of waste/recyclables
- frequency of collection
- volume (m^3) to mass conversion factor.

3.32 The Higher Education Environmental Performance Improvement (HEEPI)[39] project has produced a document to help HEIs measure their waste.

39 'Measuring and Minimising Waste Lessons from the HEEPI Project' (HEEPI 2004). Available at www.heepi.org.uk/documents/HEEPI%20Waste%20guidance%20report.pdf.

Case Study: **Waste contracts**

In March 2011 the University of Sunderland entered into a new waste contract which adopted a 'total waste' approach. This form of contract ensures that as much waste as possible is recycled with regular reports from the contractor on materials and weights, as well as ensuring all waste is disposed of through registered carriers and in accordance with current legislation.

The institution has taken a proactive approach to understanding its waste composition and the potential for further recycling by working closely with its new waste contractor. Part of this work has been to improve data returns from the contractor as well as understanding the composition of waste produced.

As part of the total waste contract, the contractor had to provide monthly reports, broken down into the different materials collected and disposed of as well as their respective weights. The reports also provided information on contamination rates. When the contract was being prepared, the institution ensured the information requested through the contractor's reports was in a form and format which enabled simple reporting to the EMS, benchmarking schemes such as Green League and public reporting through the institution's website.

The contractor also completed a detailed waste audit for the institution based on a sample collection from part of the campus. This consisted of the contractor clearing its MRF of materials and then sending only waste from the institution through the facility. It ensured that only waste from the institution was sorted and analysed.

The information provided by the waste audit gave the University of Sunderland an indication of the types of waste which can be recycled and recovered as well as a detailed breakdown of the types of waste and weights it produced. Through the waste contract, this will be completed on a more regular basis for more of the organisation to provide more detail about waste at the institution.

The institution was aware that there are materials in the general waste stream that can be recovered and/or recycled. Through working with the contractor, the institution was able to gain a better understanding of the composition of the general waste and what materials could be recovered.

The total waste contract has made it possible to recycle and reuse a wide range of materials including cans, plastics, white paper, mixed paper and batteries. There are also provisions for recycling cardboard, wood, MDF, chipboard, cardboard, all garden waste, metals, bricks, sand, ceramics, concrete, glass, plasterboard and oily rags.

Improved data collection has enabled more open and more accurate reporting through the institution's website to staff, students and other stakeholders. It has also enabled the use of key performance indicators (KPIs) and metrics to monitor performance and set targets.

Source: University of Sunderland

Hazardous waste

3.33 Hazardous waste is excluded from the carbon emissions estimation as there are no Defra/DECC conversion factors for hazardous waste. However, due to the nature of hazardous waste, HEIs will be able to report volumes of this through EMS. A consignment note must be completed by a registered waste carrier to accompany hazardous waste when it is moved from any premises. This consignment note will provide the mass (kilograms) of the waste.

Construction, demolition and excavation waste

3.34 Construction, demolition and excavation (CD&E) waste is excluded from the carbon emissions estimation because disposal of this waste is likely to be the construction contractor's responsibility. However, CD&E waste arising from construction and demolition is likely to represent a large proportion of total waste arising in an HEI and should continue to be reported as part of the EMS. Under the Site Waste Management Plan Regulations 2008, construction contractors are required to report the waste arisings on projects valued over £300,000 in a Site Waste Management Plan (SWMP). For small works projects with a value of less than £300,000, HEIs should include a contract requirement that relates to the contractor submitting waste data.

4. Other sources of guidance and support

4.1 There are several sources of guidance for institutions wishing to reduce water use and waste and associated carbon emissions. There is also a very wide range of ongoing activity across the HE sector, including sector-wide programmes and institutional initiatives.

4.2 Table 10 identifies sources of support and guidance, and provides a brief overview of some key, sector-wide activities and initiatives.

Table 10: Selected sources of support and guidance for HEIs

Resource	Description	Source
Defra's Environmental Key Performance Indicators	The use of Key Performance Indicators (KPIs) can help organisations manage and communicate links between environmental and financial performance. These Defra guidelines make this process easier by setting out 22 environmental KPIs.	www.defra.gov.uk/publications/files/pb11321-envkpi-guidelines-060121.pdf
Environmental Association for Universities and Colleges (EAUC) Resource Bank	Case studies and guidance on managing water and waste.	www.eauc.org.uk/resource_bank
EAUC Waste Management Guide	Online guidance produced by EAUC on waste management.	www.eauc.org.uk/how_to_use_the_waste_management guide
Furniture Re-use Network	The national body which supports, assists and develops charitable reuse organisations across the UK. It includes details of reuse centres.	www.frn.org.uk/
Measuring and Minimising Waste. Lessons from the HEEPI Project	This report summarises the insights gained from HEEPI's measuring and minimising waste project.	www.heepi.org.uk/documents/HEEPI%20Waste%20guidance%20report.pdf
National Industrial Symbiosis Programme NISP)	NISP is a free support programme that delivers bottom line, environmental and social benefits and is the first industrial symbiosis initiative in the UK.	www.nisp.org.uk/
Waste & Resources Action Programme (WRAP) Waste prevention	Advice and guidance on how to reduce waste and water consumption.	www.wrap.org.uk/
Why Waste	Online exchange for business waste in the Yorkshire and Humber region.	www.whywaste.org.uk/

Annex A. Carbon emission conversion factors

1. Defra, in partnership with DECC, provides guidance for businesses and organisations on how to measure and report greenhouse gas emissions.[40] This guidance is aimed at all sizes of business as well as public and third sector organisations. It also explains how existing data sources and information, such as utility bills and records of waste collection, can be used to calculate carbon emissions by applying relevant conversion factors.

2. The conversion factors below are for the year 2011 and institutions should check for updates on the Defra website.[41] These conversion factors are used for the Estate Management Statistics.

Conversion factors related to water supply and wastewater treatment

3. Table A1 contains the conversion factors for emissions associated with the supply and treatment of water. Emissions for water supply and wastewater treatment should be calculated based on their annual conversion factors as they reflect the actual emissions per volume unit occurring in the water utilities each year.

Table A1: 2011 Defra/DECC life cycle conversion factors for water

		kg CO_2e per unit		
Emission Source	**Units**	**2007/08**	**2008/09**	**2009/10**
Water supply	cubic metres [m^3]	0.276	0.300	0.340
Wastewater treatment	cubic metres [m^3]	0.693	0.750	0.700

Source: Defra/ DECC, 2011 Guidelines to Defra / DECC's GHG Conversion Factors for Company Reporting (Annex 9, Table 9a)

Conversion factors related to waste treatment and disposal

4. Table A2 contains the conversion factors for waste published in August 2011. The factors relate to individual waste fractions e.g. glass, garden waste, paper, card etc and their ultimate treatment or disposal route i.e. recycled or energy from waste recovery. These conversion factors, provided by WRAP, are updated annually taking into account process and supply chain improvements within each material sector at the national level. Institutions should use the most recent conversion factors to reflect these changes.

5. Table A3 provides examples of typical waste materials generated in HEIs and their waste fraction category.

40 'August 2011 Guidelines to Defra / DECC's Greenhouse Gas Conversion Factors for Company Reporting'. Available at www.defra.gov.uk/environment/economy/business-efficiency/reporting/.

41 For more information see www.defra.gov.uk/environment/economy/business-efficiency/reporting.

Table A2: 2011 Defra/DECC life cycle conversion factors for waste disposal

Waste fraction	Production emissions [kg CO_2e emitted per tonne of virgin material]	Net kg CO_2e emitted per tonne of waste treated/disposed by:						
		(Preparation for) Reuse [kg CO_2e]	Recycling		Energy Recovery			
			Open loop [a]	Closed loop [b]	Combustion	Anaerobic digestion	Composting	Landfill
Aggregates (Rubble)	8		No data	-4				0
Batteries (post consumer, non automotive) [c]	No data		No data		No data			75
Books	955		No data	-157	-529		57	580
Glass	895	No data	-197	-366	26			26
Metal: Aluminium cans and foil (excl. forming)	9,844			-9,245	31			21
Metal: Mixed cans	4,778			-3,889	31			21
Metal: Scrap metal	3,169			-2,241	29			20
Metal: Steel cans	2,708			-1,702	31			21
Mineral oil	1,401			-725	-1,195			0
Mixed commercial and industrial waste	1,613			-1,082	-347	-50	-30	199
Mixed municipal waste	2,053		257	-1,679	-37	-50	-15	290
Organic waste: Food and drink waste	3,590				-89	-162	-39	450
Organic waste: Garden waste					-63	-119	-42	213

Waste fraction	Production emissions [kg CO_2e emitted per tonne of virgin material]	Net kg CO_2e emitted per tonne of waste treated/disposed by:						
		(Preparation for) Reuse [kg CO_2e]	Recycling		Energy Recovery			
			Open loop [a]	Closed loop [b]	Combustion	Anaerobic digestion	Composting	Landfill
Organic waste: Mixed food and garden waste					-67	-126	-42	254
Paper and board: Board [d]	1,038		No data	-240	-529		57	580
Paper and board: Mixed paper and board [e]	1,017		No data	-219	-529		57	580
Paper and board: Paper	955		No data	-157	-529		57	580
Plasterboard	120			-67				72
Plastics: Average plastics	3,179		-282	-1,171	1,197			34
Plastics: Average plastic film (including bags)	2,591		-447	-1,042	1,057			34
Plastics: Average plastic rigid (including bottles)	3,281		-230	-1,170	1,057			34
Plastics: High Density Polyethylene (HPDE) (incl. forming)	2,789		-433	-1,127	1,057			34
Plastics: Low Density Polyethylene (LPDE) (including forming)	2,612		-458	-1,064	1,057			34
Plastics: Polyethylene Terephthalate (PET) (including forming)	4,368		-187	-1,671	1,833			34

Waste fraction	Production emissions [kg CO_2e emitted per tonne of virgin material]	Net kg CO_2e emitted per tonne of waste treated/disposed by:						
		(Preparation for) Reuse [kg CO_2e]	Recycling		Energy Recovery			
			Open loop [a]	Closed loop [b]	Combustion	Anaerobic digestion	Composting	Landfill
Plastics: Polypropylene (PP) (including forming)	3,254		12	-914	1,357			34
Plastics: Polystyrene (PS) (including forming)	4,548		368	-1,205	1,067			34
Plastics: Polyvinyl Chloride (PVC) (including forming)	3,136		14	-854	1,833			34
Silt/soil	4		16		35			20
Textiles [f]	22,310	-13,769		-13,769	600			300
Tyres	3,410	-2,900	23	0				
WEEE- Fridges and freezers	3,814	No data	-656					17
WEEE- Large	537	No data	-1,249		No data			17
WEEE – Mixed	1,149	No data	-1,357		No data			17
WEEE – Small	1,761	No data	-1,465		No data			17
Wood	666	-599	No data	-523	-817		285	792

Source: Defra/DECC, 2011 Guidelines to Defra/DECC's GHG Conversion Factors for Company (Annex 9, Table 9d).

[a] Open loop refers to product systems where the material is recycled into other product systems and the material undergoes a change to its inherent properties.

[b] Closed loop refers to product systems where no changes occur in the inherent properties of the recycled material. In such cases, the use of secondary material displaces the use of virgin (primary) materials.

[c] For automotive batteries use the conversion factors related to mixed commercial and industrial waste.

[d] Average board: 78 per cent corrugate, 22 per cent cardboard.

[e] Assumed 25 per cent paper, 75 per cent board.

[f] Benefits of recycling and reuse of textiles is based on 60 per cent reused, 30 per cent recycled (replacing paper towels), 10 per cent landfill. Of the items reused, 80 per cent are assumed to avoid new items.

Table A3: Waste fractions categories and examples of typical waste materials

Waste fractions	Typical waste materials generated in HEIs
Paper	• Office waste paper • Confidential shredding paper • Wrapping papers • Newspapers and magazines • Packaging paper • Envelopes • Hand towels • Paper plates and cups
Cardboard	• Corrugated board • Carton board (white line chipboard, solid board, folding box board, boxcard) • Liquid cartons • Other card
Books	• Books • Directories and catalogues
Food and drink waste	• Raw food and vegetable matter • Cooked food
Garden waste	• Grass cuttings • Hedge trimmings
Wood	• Wooden packaging • Wood pallets • Wooden containers
Textiles	• Clothing • Shoes • Bed linen, duvets, pillows • Handbags • Soft toys
Glass	• Glass bottles and jars
Metals	• Steel food and beverage cans • Aerosols • Tinplate coil packaging • Aluminium cans and foils
Plastic – Polyethylene Terephthalate (PET) (considered as plastic-dense)	• PET bottles (plastic PET) (commonly used by the beverage industry) • Fibre for stuffing • Carpets • PET packaging

Waste fractions	Typical waste materials generated in HEIs
Plastic – Polystyrene (PS) (considered as plastic-dense)	• PS products, including cups • Loose fill packaging • Stationery • Garden furniture • High impacts polystyrene packaging (e.g. yogurt pots) • Building products
Plastic – High Density Polyethylene (HPDE) (considered as plastic-dense)	• HPDE bottles (commonly used for milk packaging) • HPDE rigid boxes and crates • Bins • Underground pipes • Other packaging
Plastics – Polyvinyl Chloride (PVC) (considered as plastic-dense)	• PVC building products • PVC medical products (e.g. gloves)
Plastics – Polypropylene (PP) (considered as plastic film)	• PP trays, boxes and crates • PP refuse sacks • PP carrier bags • PP film • PP chemical containers
Mixed municipal waste [a]	• Mixed recyclables • Unknown general waste
Mixed commercial and industrial waste [b]	• Industrial waste • Trade waste [c]
Hazardous waste	• Asbestos • Chemicals (e.g. brake fluid and printer toner) • WEEE with potentially harmful components such as cathode ray tubes (e.g. computer monitors and televisions), fluorescent light tubes and energy-saving light bulbs • Vehicle and other lead-acid batteries • Oils (except edible oils) (e.g. engine oil) • Refrigerators containing ozone-depleting substances • Solvents (e.g. aerosols) • Pesticides • Healthcare/clinical (e.g. sharps, body fluids, animal waste, dressings, sanitary waste and drugs or other pharmaceutical products)
Sanitary waste (personal hygiene)	• Sanitary towels • Tampons • Nappies

[a] Municipal waste is that which comes under the control of the local authority and includes household waste and other wastes collected by a waste collection authority or its agents, such as municipal parks and gardens waste, beach cleansing waste and waste resulting from the clearance of fly-tipped materials.

[b] This category can comprise hazardous and non-hazardous waste produced on commercial and industrial business' premises as well as institutions excluding construction and demolition waste and municipal waste. This category may include chemical wastes (solvents, acids/alkalis, used oil, catalysts, wastes from chemical preparation, residues and sludge), healthcare wastes, metallic wastes, non-metallic waste (glass, paper and card, rubber, plastic, wood, textiles), discarded equipment (end of life vehicles, batteries, waste electronics and other discarded equipment), animal and vegetable waste (food, manure, other animal and vegetable wastes), mixed ordinary waste (undifferentiated waste and sorting residues), common sludges (sludges and dredging wastes) and mineral wastes (combustion residues, contaminated soils, solidified mineral wastes and other mineral wastes).

[c] Trade waste refers to the waste generated by a commercial process or operation, including construction and demolition waste. Trade waste is often a term used by a number of local authorities in relation to collection services they provide for commercial and industrial waste.

Annex B. National waste datasets

1. Where data on different waste fractions are not available from waste contractors it is possible to use information from national waste datasets. National waste datasets provide an estimate of different waste fractions within waste streams and the potential waste mass within those fractions. Conversion factors can then be applied to estimated waste fractions to provide an estimate of the associated GHG emissions for the waste.

2. Waste compositional data vary over time and, therefore, the national waste datasets need to be updated periodically when studies at national level or in the HE sector are conducted. Reliable sources of information for these national waste datasets are indicated in the following subsections.

Waste Watch Further and Higher Education Institutions (FHEI) compositional data

3. Waste Watch is a UK environmental charity promoting sustainable resource use. Waste Watch campaigns through policy development for all areas of society to reduce, reuse and recycle. It also works to change attitudes and behaviour through projects and services in communications, education, information and research.

4. Waste Watch completed a study of resource management in the education sector in 2005.[42] The study engaged with different levels of the education system including primary schools, secondary schools, further education colleges and HEIs. Specifically, the study looked at environmental management, purchasing, energy and water use, the use of other physical resources and waste. One output of the study was a compositional breakdown of waste produced by participating institutions. This information (Table B1) provides good evidence of the composition of waste in the sector and can be used for non-residential buildings.

Table B1: Waste Watch FHEI waste composition

Waste fractions	Estimated composition
Paper and cardboard	55%
Metal	18%
Glass	17%
Plastic	2%
Food and green waste	4%
Other	4%
Total	**100%**

Source: Waste Watch, 2005. Resource management in the education sector: key findings from a study

42 'Resource management in the education sector: key findings from a study' (Waste Watch 2005). Available at www.thinkleadership.org.uk/pdf/EducationSectorReport-final.pdf.

Defra Municipal Waste

5. The Defra municipal waste dataset has been compiled by Resource Futures from various studies relating to municipal waste.[43] The dataset combines findings and information from local authorities, contractors that provide waste auditing services to local authorities, and from the Defra Local Authority Support Unit and the Waste Information Network. The study provides the detailed waste composition of municipal waste across the UK (Table B2). This data can be used for residential buildings.[44]

Table B2: Defra municipal waste composition

Waste fractions	Estimated composition
Food waste	31%
Garden waste	1%
Paper and card	39%
Glass	1%
Metals	4%
Dense plastic	10%
Plastic film	7%
Textiles	1%
WEEE	0%
Hazardous waste	0%
Miscellaneous	3%
Batteries	0%
Fines	3%
Total	**100%**

Source: Defra, 2008. Municipal Waste Composition: A Review of Municipal Waste Component Analyses

[43] Resource Futures on behalf of Defra (2008). Municipal Waste Composition: A Review of Municipal Waste Component Analyses.

[44] Updates for municipal waste compositional data are not currently available on an annual or fixed periodic basis. The updates currently depend on research projects conducted by Defra. As waste data reporting improves and becomes more detailed it is likely that municipal waste compositional data will be available on a more regular basis. The most recent municipal waste compositional data illustrated in Table B2 can be found at http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=15133.

Annex C. Worked examples for estimating carbon emissions from water and waste

1. These worked examples are presented to help institutions understand how carbon emissions can be calculated using the proposed EMS definitions.

2. Results from the worked examples 3, 4 and 5 may differ slightly from the emissions calculated through the Defra/DECC spreadsheet (paragraph 3.16) due to decimals fractions not considered in the conversion factors figures used to calculate the examples (shown in Table A2 which present rounded figures).

Worked example 1: Estimation of water supply carbon emissions

HEI 1 reported the following data in the EMS in 2008/09:

D38 Water consumption non-residential (C13): 65,830 m^3

D38 Water consumption residential (C14): 12,751 m^3

D38 Water consumption total estate(C1): 78,581 m^3

General formula:

$GHG_{\text{water supply}} = [kg\ CO_2e] = \text{water supply volume}\ [m^3] * CF_{\text{water supply}}\ [kg\ CO_2e/m3]$

where CF water supply (2008/09) = 0.3 kg CO_2e/m^3 (see Table A1)

$GHG_{\text{water supply}}$ (C13) = 65,830 m^3 * 0.3 kg CO_2e/m^3 = 19,749 kg CO_2e

$GHG_{\text{water supply}}$ (C14) = 12,751 m^3 * 0.3 kg CO_2e/m^3 = 3,825 kg CO_2e

$GHG_{\text{water supply}}$ (C1) = GHG water supply (C13) + GHG water supply (C14) = 19,749 + 3,825

$GHG_{\text{water supply}}$ (C1) = 23,574 kg CO_2e

Worked example 2: Wastewater treatment GHG emissions

HEI 2 reported the following data in the EMS in 2008/09:

D38 Water consumption total estate (C1): 33,662m^3

D77a Water supply of greywater and rainwater: 0 m^3

D77b Water supply from borehole extraction: 85 m^3

General formulae:

$GHG_{\text{wastewater}}\ [kg\ CO_2e] = \text{Total wastewater volume}\ [m^3] * CF_{\text{wastewater}}\ [kg\ CO_2e/m^3]$

where $CF_{\text{wastewater}}$ (2008/09) = 0.75 kg CO_2e/m^3 (see Table A1)

Taking into account the water that is consumed in the HEI (using 95 per cent of water supplied as a default value)

Wastewater volume from water consumption = 33,662 m^3 * 95% = 31,979 m^3

Total wastewater volume = wastewater volume from water consumption + greywater or rainwater volume + borehole extraction water volume

Total wastewater volume = 31,979 m^3 + 0 m^3 + 85 m^3 = 32,064 m^3

GHG $_{wastewater}$ (C1) = 32,064 m3 * 0.75 kg CO2e/m3

GHG $_{wastewater}$ (C1) = 24,048 kg CO_2e

Worked example 3: Basic approach to estimate waste GHG emissions (residential estate)

HEI 3 only has the following data:

D73 Waste mass residential (C14): Not reported

Unknown amounts of waste mass sent different treatment methods

Number of students in residences = 1,000 (internal records)

From national statistics:

Per capita municipal waste generated (2009/10) = 0.526 tonnes waste/person

UK national average of municipal waste recycled (2009/10) = 24 per cent

UK national average of municipal waste composted (2009/10) = 15.7 per cent

Step H:

Total waste mass = Number of students * per capita municipal waste generated

Total waste mass = (1,000 students) * (0.526 tonnes waste/person) = 526 tonnes waste

Step I (net emissions associated with recycling):

Waste mass $_{recycled}$ = total waste mass * UK national average of municipal waste recycled

Waste mass $_{recycled}$ = 526 tonnes * 24% = 126.2 tonnes waste recycled

GHG $_{recycling}$ = Waste mass $_{recycled}$ * CF $_{open\ loop\ recycling\ (mixed\ municipal\ waste)}$

CF $_{open\ loop\ recycling\ (mixed\ municipal\ waste)}$ = 257 kg CO_2e/tonne (see Table A2)

GHG $_{recycling}$ = (126.2 tonnes) * (257 kg CO_2e/tonne) = 32,433 kg CO_2e

Step J (net emissions associated with composting and/or anaerobic digestion):

Waste mass $_{composting}$ = total waste mass * UK national average of municipal waste composted

Waste mass $_{composting}$ = 526 tonnes * 15.7% = 82.6 tonnes waste composted

GHG $_{composting}$ = Waste mass $_{composting}$ * CF $_{composting\ (mixed\ municipal\ waste)}$

CF $_{composting\ (mixed\ municipal\ waste)}$ = -15 kg CO_2e/tonne (see Table A2)

GHG $_{composting}$ = (82.6 tonnes) * (-15 kg CO_2e/tonne) = -1, 239 kg CO_2e

Step K (net emissions associated with energy from waste):

Waste mass $_{EfW}$ = 0 tonnes

GHG $_{EfW}$ = 0 kg CO_2e

Step L (net emissions associated with waste disposal in landfills):

Waste mass $_{landfill}$ = total waste mass – waste mass $_{recycled}$ – waste mass $_{composted}$ – waste mass $_{EfW}$

Waste mass $_{landfill}$ = 526 tonnes – 126.2 tonnes – 82.6 tonnes – 0 tonnes = 317.2 tonnes

GHG $_{landfill}$ = Waste mass $_{landfill}$ * CF $_{landfill\ (mixed\ municipal\ waste)}$

CF $_{landfill\ (mixed\ municipal\ waste)}$ = 290 kg CO_2e/tonne (see Table A2)

GHG $_{landfill}$ = (317.2 tonnes) * (290 kg CO_2e/tonne) = 91,988 kg CO_2e

Step M (net emissions from waste production of virgin material):

GHG $_{production\ (mixed\ municipal\ waste)}$ = Total waste mass * CF $_{production\ (mixed\ municipal\ waste)}$

CF $_{production\ (mixed\ municipal\ waste)}$ = 2,053 kg CO_2e/tonne (see Table A2)

GHG $_{production\ (mixed\ municipal\ waste)}$ =
(526 tonnes) * (2,053 kg CO_2e/tonne) = 1,079,878 kg CO_2e

Step N (net emissions from various waste disposal routes):

Net GHG (C14) = GHG $_{production}$ + [GHG $_{recycling}$ + GHG $_{composting}$ + GHG $_{EfW}$ + GHG $_{landfill}$]

Net GHG (C14) = (1,079,878) + [32,433 + (-1,239) + 0 + 91,988]

Net GHG (C14) = 1,203,060 kg CO_2e

Worked example 4: Medium approach to estimate waste GHG emissions (non-residential estate)

HEI 4 reported the following data in the EMS in 2008/09:

D73 Waste mass non-residential (C13) total: 712 tonnes

D73 Waste mass non-residential (C13) recycled: 231 tonnes

D73 Waste mass non-residential (C13) other: 481 tonnes (landfill)

Internal records:

Paper recycled: 129 tonnes

Cardboard recycled: 53 tonnes

Wood recycled: 20 tonnes

Metal recycled: 22 tonnes

Plastic recycled: 6 tonnes

Cans recycled: 1 tonne

General formula for estimating GHG emissions from waste fractions sent to various disposal routes:

$GHG_{\text{waste fraction, waste treatment}} =$
$(\text{Waste mass}_{\text{waste fraction, waste treatment}}) * CF_{\text{waste fraction, waste treatment}}$

Step B (net emissions associated with recycling):

For GHG conversion factors, see Table A2, 'Recycling' (fourth or fifth columns):

Paper

$GHG_{\text{paper recycled}}$ = (129 tonnes) * (-157 kg CO_2e/tonne) = -20,253 kg CO_2e

Board (average)

$GHG_{\text{cardboard recycled}}$ = (53 tonnes) * (-240 kg CO_2e/tonne) = -12,720 kg CO_2e

Wood

$GHG_{\text{wood recycled}}$ = (20 tonnes) * (-523 kg CO_2e/tonne) = -10,460 kg CO_2e

Metal: scrap metal

$GHG_{\text{metal recycled}}$ = (22 tonnes) * (-2,241 kg CO_2e/tonne) = -49,302 kg CO_2e

Average plastics

$GHG_{\text{plastic recycled}}$ = (6 tonnes) * (-282 kg CO_2e/tonne) = -1,692 kg CO_2e

Metals: mixed cans

$GHG_{\text{cans recycled}}$ = (1 tonne) * (-3,889 kg CO_2e/tonne) = -3,889 kg CO_2e

Step C (net emissions associated with composting and/or anaerobic digestion):

$GHG_{\text{total composted}} = 0 \text{ kg } CO_2e$

$GHG_{\text{total anaerobic digestion}} = 0 \text{ kg } CO_2e$

Step D (net emissions associated with energy from waste):

$GHG_{\text{total EfW}} = 0 \text{ kg } CO_2e$

Step E (net emissions associated with waste disposal in landfills):

Estimated waste compositional data for waste sent to landfill:

Waste fraction	Estimated composition (see Table B1)	Waste to landfill [tonnes]
Paper and cardboard	55%	265
Food and green waste	18%	87
Plastics	17%	82
Metals	2%	10
Glass	4%	19
Other	4%	19
Total	**100%**	**481**

For GHG conversion factors, see Table A2, 'Landfill' (last) column:

It is recommended to apply a 50/50 % split for waste mass of paper, cardboard:

Paper

$GHG_{\text{paper landfill}} = (132.5 \text{ tonnes}) * (580 \text{ kg } CO_2e/\text{tonne}) = 76{,}850 \text{ kg } CO_2e$

Board (average)

$GHG_{\text{cardboard landfill}} = (132.5 \text{ tonnes}) * (580 \text{ kg } CO_2e/\text{tonne}) = 76{,}850 \text{ kg } CO_2e$

Organic waste: mixed food and garden waste

$GHG_{\text{food and green waste landfill}} = (87 \text{ tonnes}) * (254 \text{ kg } CO_2e/\text{tonne}) = 22{,}098 \text{ kg } CO_2e$

Average plastics

$GHG_{\text{plastics landfill}} = (82 \text{ tonnes}) * (34 \text{ kg } CO_2e/\text{tonne}) = 2{,}788 \text{ kg } CO_2e$

Metals: scrap metal

$GHG_{\text{metals landfill}} = (10 \text{ tonnes}) * (20 \text{ kg } CO_2e/\text{tonne}) = 200 \text{ kg } CO_2e$

Glass

$GHG_{\text{glass landfill}} = (19 \text{ tonnes}) * (26 \text{ kg } CO_2e/\text{tonne}) = 494 \text{ kg } CO_2e$

Other: mixed municipal waste

$GHG_{\text{other landfill}} = (19 \text{ tonnes}) * (290 \text{ kg } CO_2e/\text{tonne}) = 5{,}510 \text{ kg } CO_2e$

Step F (net emissions from waste production of virgin material):

General formula for estimating emissions from production of virgin material:

$GHG_{\text{waste fraction, production}} =$
$(\Sigma \text{Waste mass}_{\text{waste fraction, waste treatment}}) * CF_{\text{waste fraction, production}}$

For GHG conversion factors, see Table A2, 'Production emissions' (second) column:

Paper

$GHG_{\text{production (paper)}}$ = (129 + 132.5 tonnes) * (955 kg CO_2e/tonne) = 249,733 kg CO_2e

Board (average)

$GHG_{\text{production (cardboard)}}$ = (53 + 132.5 tonnes) * (1,038 kg CO_2e/tonne) = 192,549 kg CO_2e

Organic waste: mixed food and garden waste

$GHG_{\text{production (food and green waste)}}$ = (87 tonnes) * (0 kg CO_2e/tonne) = 0 kg CO_2e

Wood

$GHG_{\text{production (wood)}}$ = (20 tonnes) * (666 kg CO_2e/tonne) = 13,320 kg CO_2e

Metals: scrap metal

$GHG_{\text{production (metals)}}$ = (22 + 10 tonnes) * (3,169 kg CO_2e/tonne) = 101,408 kg CO_2e

Average plastics

$GHG_{\text{production (plastics)}}$ = (6 + 82 tonnes) * (3,179 kg CO_2e/tonne) = 279,752 kg CO_2e

Glass

$GHG_{\text{production (glass)}}$ = (19 tonnes) * (895 kg CO_2e/tonne) = 17,005 kg CO_2e

Metals: mixed cans

$GHG_{\text{production (cans)}}$ = (1 tonne) * (4,778 kg CO_2e/tonne) = 4,778 kg CO_2e

Other (mixed municipal waste)

$GHG_{\text{production (mixed municipal waste)}}$ = (19 tonnes) * (2,053 kg CO_2e/tonne) = 39,007 kg CO_2e

Step G (net emissions from various waste disposal routes):

$\text{Net } GHG_{\text{paper}} = GHG_{\text{production (paper)}} + [GHG_{\text{paper recycled}} + GHG_{\text{paper landfill}}]$

$\text{Net } GHG_{\text{paper}}$ = 249,733 + [-20,253 + 76,850] = 306,330 kg CO_2e

$\text{Net } GHG_{\text{cardboard}} = GHG_{\text{production (cardboard)}} + [GHG_{\text{cardboard recycled}} + GHG_{\text{cardboard landfill}}]$

$\text{Net } GHG_{\text{cardboard}}$ = 192,549 + [-12,720 + 76,850] = 256,679 kg CO_2e

$\text{Net } GHG_{\text{food and green waste}} = GHG_{\text{production (food and green waste)}} + [GHG_{\text{food and green waste landfill}}]$

$\text{Net } GHG_{\text{food and green waste}}$ = 0 + 22,098 = 22,098 kg CO_2e

Net GHG $_{wood}$ = GHG $_{production (wood)}$ + [GHG $_{wood recycled}$] = 13,320 + [-10,460] = 2,860 kg CO_2e

Net GHG $_{metals}$ = GHG $_{production (metals)}$ + [GHG $_{metals recycled}$ + GHG $_{metals landfill}$]

Net GHG $_{metals}$ = 101,408 + [-49,302 + 200] = 52,306 kg CO_2e

Net GHG $_{plastics}$ = GHG $_{production (plastics)}$ + [GHG $_{plastics recycled}$ + GHG $_{plastics}$ landfill]

Net GHG $_{plastics}$ = 279,752 + [-1,692 + 2,788] = 280,848 kg CO_2e

Net GHG $_{glass}$ = GHG $_{production (glass)}$ + [GHG $_{glass landfill}$]

Net GHG $_{glass}$ = 17,005 + [494] = 17,499 kg CO_2e

Net GHG $_{cans}$ = GHG $_{production (cans)}$ + [GHG $_{cans recycled}$]

Net GHG $_{cans}$ = 4,778 + [-3,389] = 889 kg CO_2e

Net GHG $_{mixed municipal waste}$ =
GHG production (mixed municipal waste) + [GHG $_{municipal waste landfill}$]

Net GHG $_{mixed municipal waste}$ = 39,007 + [5,510] = 44,517 kg CO_2e

Net GHG (C13) = Net GHG $_{paper}$ + Net GHG $_{cardboard}$ + Net GHG $_{food and green waste}$ + Net GHG $_{wood}$ + Net GHG $_{metals}$ + Net GHG $_{plastics}$ + Net GHG $_{glass}$ + Net GHG $_{cans}$ + Net GHG $_{mixed municipal waste}$

Net GHG (C13) = 984,026 kg CO_2e

Worked example 5: Detailed approach to estimate waste GHG emissions (residential estate)

HEI 5 reported the following data in the EMS in 2008/09:

D73 Waste mass residential (C14) total = 113.2 tonnes

D73 Waste mass residential (C14) recycled = 100.1 tonnes

D73 Waste mass residential (C14) other = 13.1 tonnes (landfill)

Internal records (obtained from waste management contractor):

Waste fractions	Total waste collected [tonnes]	Waste recycled [tonnes]	Waste sent to landfill [tonnes]
Glass	3.2	3.2	
Paper	19.1	15.1	4.0
Plastic	28.7	22.7	6.0
Commercial waste	40.8	37.8	3.0
Food waste	1.1	1.1	
Industrial waste	0.5	0.4	0.1
Mixed recyclables	19.8	19.8	
Total	**113.2**	**100.1**	**13.1**

Step I (net emissions associated with recycling):

Mixed recyclables: 19.8 tonnes

Waste management contractor dry recyclable figures:

- Paper (50%)
- Card (30%)
- Plastics (13%)
- Cans (5%)
- Residue (2%)

Waste fractions	Waste recycled separately [tonnes]	Waste recycled through MRF [tonnes]	Total waste recycled [tonnes]
Glass	3.2	-	3.2
Paper	15.1	9.9	25.0
Card	-	5.9	5.9
Plastics	22.7	2.6	25.3
Commercial waste	37.8	-	37.8
Food waste	1.1	-	1.1
Industrial waste	0.4	-	0.4
Cans	-	1.0	1.0
Residue	-	0.4	0.4
Total	**80.3**	**19.8**	**100.1**

General formula for estimating GHG emissions from waste fractions sent to various disposal routes:

$GHG_{\text{waste fraction, waste treatment}} = (\text{Waste mass}_{\text{waste fraction, waste treatment}}) * CF_{\text{waste fraction, waste treatment}}$

For GHG conversion factors, see Table A2, 'Recycling' (fourth or fifth) columns:

Glass

$GHG_{\text{glass recycled}}$ = (3.2 tonnes) * (-366 kg CO_2e/tonne) = -1,171 kg CO_2e

Paper

$GHG_{\text{paper recycled}}$ = (25 tonnes) * (-157 kg CO_2e/tonne) = -3,925 kg CO_2e

Board (average)

$GHG_{\text{card recycled}}$ = (5.9 tonnes) * (-240 kg CO_2e/tonne) = -1,416 kg CO_2e

Average plastics

$GHG_{\text{plastic recycled}}$ = (25.3 tonnes) * (-282 kg CO_2e/tonne) = -7,135 kg CO_2e

Commercial and industrial waste

$GHG_{\text{commercial and industrial recycled}}$ = (37.8 + 0.4 tonnes)*(-1,082 kg CO_2e/tonne)=-41,332 kg CO_2e

Metal: mixed cans

$GHG_{\text{cans recycled}}$ = (1 tonne) * (-3,889 kg CO_2e/tonne) = -3,889 kg CO_2e

Residual (mixed municipal waste)

$GHG_{\text{residual recycled}}$ = (0.4 tonne) * (257 kg CO_2e/tonne) = 103 kg CO_2e

Step J (net emissions associated with composting and/or anaerobic digestion):

For GHG conversion factors, see Table A2, 'Composting' (eighth) column:

Organic waste: Food and drink waste

$GHG_{\text{food waste composted}}$ = (1.1 tonnes) * (-39 kg CO_2e/tonne) = -43 kg CO_2e

Step K (net emissions associated with energy from waste):

$GHG_{\text{total EfW}}$ = 0 kg CO_2e

Step L (net emissions associated with waste disposal in landfills):

For GHG conversion factors, see Table A2, 'Landfill' (last) column:

Paper

$GHG_{\text{paper landfill}}$ = (4 tonnes) * (580 kg CO_2e/tonne) = 2,320 kg CO_2e

Average plastics

$GHG_{\text{plastics landfill}}$ = (6 tonnes) * (34 kg CO_2e/tonne) = 204 kg CO_2e

Commercial and industrial waste

$GHG_{\text{commercial and industrial landfill}}$ = (3.1 tonnes) * (199 kg CO_2e/tonne) = 617 kg CO_2e

Step M (net emissions from waste production of virgin material):

General formula for estimating emissions from production of virgin material:

$$GHG_{\text{waste fraction, production}} = (\sum \text{Waste mass}_{\text{waste fraction, waste treatment}}) * CF_{\text{waste fraction, production}}$$

For GHG conversion factors, see Table A2, 'Production emissions' (second) column:

Glass

$GHG_{\text{production (glass)}}$ = (3.2 tonnes) * (895 kg CO_2e/tonne) = 2,864 kg CO_2e

Paper

$GHG_{\text{production (paper)}}$ = (25 + 4 tonnes) * (955 kg CO_2e/tonne) = 27,695 kg CO_2e

Board (average)

$GHG_{\text{production (card)}}$ = (5.9 tonnes) * (1,038 kg CO_2e/tonne) = 6,124 kg CO_2e

Average plastics

$GHG_{production\ (plastics)} = (25.3 + 6\ tonnes) * (3{,}179\ kg\ CO_2e/tonne) = 99{,}503\ kg\ CO_2e$

Commercial and industrial waste

$GHG_{production\ (commercial\ and\ industrial\ waste)} = (38.2+3.1\ tonnes) * (1{,}613\ kg\ CO_2e/tonne) = 66{,}617\ kg\ CO_2e$

Organic waste: food and drink waste

$GHG_{production\ (food\ waste)} = (1.1\ tonnes) * (3{,}590\ kg\ CO_2e/tonne) = 3{,}949\ kg\ CO_2e$

Metals: mixed cans

$GHG_{production\ (cans)} = (1\ tonne) * (4{,}778\ kg\ CO_2e/tonne) = 4{,}778\ kg\ CO_2e$

Residual (mixed municipal waste)

$GHG_{production\ (residual)} = (0.4\ tonnes) * (2{,}053\ kg\ CO_2e/tonne) = 821\ kg\ CO_2e$

Step N (net emissions from various disposal routes):

$Net\ GHG_{glass} = GHG_{production\ (glass)} + [GHG_{glass\ recycled}]$

$Net\ GHG_{glass} = 2{,}864 + [-1{,}171] = 1{,}693\ kg\ CO_2e$

$Net\ GHG_{paper} = GHG_{production\ (paper)} + [GHG_{paper\ recycled} + GHG_{paper\ landfill}]$

$Net\ GHG_{paper} = 27{,}695 + [-3{,}925 + 2{,}320] = 26{,}090\ kg\ CO_2e$

$Net\ GHG_{card} = GHG_{production\ of\ virgin\ material\ (card)} + [GHG_{card\ recycled}]$

$Net\ GHG_{card} = 6{,}124 + [-1{,}416] = 4{,}708\ kg\ CO_2e$

$Net\ GHG_{plastics} = GHG_{production\ (plastics)} + [GHG_{plastics\ recycled} + GHG_{plastics\ landfill}]$

$Net\ GHG_{plastics} = 99{,}503 + [-7{,}135 + 204] = 92{,}572\ kg\ CO_2e$

$Net\ GHG_{commercial\ and\ industrial} = GHG_{production\ (commercial\ and\ industrial)} + [GHG_{commercial\ and\ industrial\ recycled} + GHG_{commercial\ and\ industrial\ landfill}]$

$Net\ GHG_{commercial\ and\ industrial} = 66{,}617 + [-41{,}332 + 617] = 25{,}901\ kg\ CO_2e$

$Net\ GHG_{food\ waste} = GHG_{production\ (food\ waste)} + [GHG_{food\ waste\ composted}]$

$Net\ GHG_{food\ waste} = 3{,}949 + [-43] = 3{,}906\ kg\ CO_2e$

$Net\ GHG_{cans} = GHG_{production\ (cans)} + [GHG_{cans\ recycled}]$

$Net\ GHG_{cans} = 4{,}778 + [-3{,}889] = 889\ kg\ CO_2e$

$Net\ GHG_{residual} = GHG_{production\ (mixed\ municipal\ waste)} + [GHG_{mixed\ municipal\ waste\ recycled}]$

$Net\ GHG_{residual} = 821 + [103] = 924\ kg\ CO_2e$

$Net\ GHG\ (C14) = Net\ GHG_{glass} + Net\ GHG_{paper} + Net\ GHG_{card} + Net\ GHG_{plastics} + Net\ GHG_{miscellaneous} + Net\ GHG_{food\ waste} + Net\ GHG_{industrial\ waste} + Net\ GHG_{cans} + Net\ GHG_{residual}$

Net GHG (C14) = 156,684 kg CO_2e

Terms and acronyms

AMR	Automatic meter reading
Anaerobic digestion	Anaerobic digestion is a waste management and renewable energy technology which can reduce greenhouse gas emissions by capturing methane from the decomposition of organic materials such as garden and food wastes. The treatment process produces biogas which can be used to generate heat and power or as a transport fuel. The process output material (digestate) can be used as a fertiliser and soil conditioner.
Arup	Ove Arup & Partners Ltd
Autoclaving	Autoclaving involves high-pressure sterilisation of waste by steam to destroy bacteria in the waste. This process is widely used to treat clinical waste, but is starting to be used as a treatment for municipal waste. Autoclaving of municipal waste is a form of 'mechanical heat treatment', a process that uses thermal treatment in conjunction with mechanical processing.
CD&E	Construction, demolition and excavation
CF	GHG conversion factor
CH4	Methane
CHP	Combined heat and power
Closed loop	Closed loop refers to product systems where no changes occur in the inherent properties of the recycled material. In such cases, the use of secondary material displaces the use of virgin (primary) materials.
CO_2	Carbon dioxide
Commercial and industrial waste	This category can comprise hazardous and non-hazardous waste produced on commercial and industrial business premises as well as institutions excluding construction and demolition waste and municipal waste. This category may include chemical wastes (solvents, acids/alkalis, used oil, catalysts, wastes from chemical preparation, residues and sludge), healthcare wastes, metallic wastes, non-metallic waste (glass, paper and card, rubber, plastic, wood, textiles), discarded equipment (end-of-life vehicles, batteries, waste electronics and other discarded equipment), animal and vegetable waste (food, manure, other animal and vegetable wastes), mixed ordinary waste (undifferentiated waste and sorting residues), common sludges (sludges and dredging wastes) and mineral wastes (combustion residues, contaminated soils, solidified mineral wastes and other mineral wastes). (See www.defra.gov.uk/news/2010/11/10/waste-arisings-stats/)

Composting	Composting is a process that can be used to recover waste by decomposing organic materials and recycling them as a fertilizer and soil conditioner. The use of compost reduces harmful emissions of the greenhouse gas methane from landfills, it reduces the need for scarce natural resources such as peat and returns organic matter to the soil.
DCSF	Department for Children, Schools and Families
DECC	Department of Energy and Climate Change
Defra	Department for Environment, Food and Rural Affairs
DMU	De Montfort University
EAUC	Environmental Association for Universities and Colleges
EfW	Energy from Waste
EMS	Estate Management Statistics
EU	European Union
FHEI	Further and Higher Education Institutions
GHG	Greenhouse gas
Hazardous waste	Hazardous waste contains materials that provide a risk to the public or to the environment (e.g. batteries, paints, solvents etc.).
HDPE	High Density Polyethylene
HE	Higher Education
HEFCE	Higher Education Funding Council for England
HEEPI	Higher Education Environmental Performance Improvement
HEIs	Higher Education Institutions
HESA	Higher Education Statistics Agency
KPIs	Key Performance Indicators
Landfill	Landfill is short for 'landfill sites' where local authorities and industry take waste to be buried and compacted. Landfill sites produce greenhouse gas emissions such as methane when biodegradable waste decomposes in anaerobic conditions.
LCA	Life Cycle Assessment
m^3	Cubic metres
MBT	Mechanical biological treatment
Municipal waste	Municipal waste is that which comes under the control of the local authority and includes household waste and other wastes collected by a waste collection authority or its agents, such as municipal parks and gardens waste, beach cleansing waste and waste resulting from the clearance of fly-tipped materials. (See www.wrap.org.uk/local_authorities/research_guidance/online_recycling_information_system_oris/glossary_of.html)

MRF	Materials recovery facility
Mt CO_2e	Million metric tonnes of carbon dioxide equivalent
NHS	National Health Service
N_2O	Nitrous oxide
NISP	National Industrial Symbiosis Programme
Open loop	Open loop refers to product systems where the material is recycled into other product systems and the material undergoes a change to its inherent properties.
PET	Polyethylene Terephthalate
PP	Polypropylene
PS	Polystyrene
PVC	Polyvinyl Chloride
Recycling	The process of sorting, cleaning, treating and reconstituting materials for the purpose of using the material in the manufacture of a new product.
Reuse	Making use of a material without altering its form. Materials can be reused on-site or reused on other projects off-site.
Scope 3 emissions	An optional reporting category for an organisation's indirect GHG emissions which are a consequence of the organisation's activities but occur from sources not owned or controlled by the organisation. Examples include 'upstream' emissions from the production and transportation of purchased goods, and 'downstream' emissions from the use and disposal of the organisation's products and services
SWMP	Site Waste Management Plan
Trade waste	Waste generated by a commercial process or operation, including construction and demolition waste. Trade waste is often a term used by a number of local authorities in relation to collection services they provide for commercial and industrial waste.
WBCSD	World Business Council for Sustainable Development
WEEE	Waste electrical and electronic equipment
WRAP	Waste & Resources Action Programme
WRI	World Resources Institute

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